Blasting Potash near Carlsbad, New Mexico

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The following case history involves several issues, the understanding of which might save underground blasters a considerable amount of time and money.

In June of 1992, I was asked to investigate blasting problems at an underground potash mine near Carlsbad, New Mexico. The basic complaint was poor fragmentation. They were either getting excessive fines or large blocky material, and sometimes both, out of the same shot. They were looking for consistency so that the potash could be processed by the mill.

Potash is mostly used as fertilizer, with a small percentage going into building materials. At this particular property the potash was langbeinite, which is harder and more abrasive than other potash minerals. It is located in a horizontal layer that varies from a few inches up to about 10 feet thick and lies approximately 700 feet below the surface. Access is by vertical shaft. At the time, it was being mined using a room-and-pillar method where pillars are left to support the roof while the layer of potash is being removed. When the outer economical limit of the deposit was reached, they would install wooden cribbing (usually old railroad ties) and blast out the pillars as they retreated.

Prior to my being requested to investigate, technical people from the explosives manufacturer supplying the mine had tried several initiation timing and/or loading schemes to alleviate the problem, but hadn't been able to achieve any improvements. In fact, several attempts had the opposite effect, resulting in too much fine material.

A typical blast round would involve an area 28 feet wide (between pillars) by 9 or 10 feet high containing approximately 93 cubic yards. Three rows of 7 holes were drilled horizontally approximately 10 feet deep. Originally the holes had been 1-3/4" diameter, but the mine had recently switched to 1-5/8" holes. When the deposit height became less than 7 feet, only two rows of holes were used.

The holes were being primed with Ensign-Bickford Salt Mine Series Primaline Primadets. Primaline is a 4 grain per foot miniature detonating cord that is totally consumed during initiation and was being used because it wouldn't contaminate the end product. Although the Primadets were of sufficient strength by themselves to shoot properly formulated Ammonium Nitrate and Fuel Oil (AN/FO), slip-on boosters were also being used.

The initiator/booster combination was pushed to the bottom of the hole, priming in an indirect manner (initiator pointing toward the bottom rather than the collar of the hole). This was being done because of concerns that the booster, if folded back and pointed toward the collar, could possibly be set off by the Primaline, negating the delay element in the Primadet.

In the bottom row, the center five holes had 25 ms delays, with 400 ms in the two end holes. The second row used 400 ms in the center five holes, with 600 ms in the end holes. The top row used 600 ms in the center five holes, with 800 ms in the end holes. This is a fairly typical timing pattern in this type of potash or in salt formations and had historically given them good results.

The holes were loaded pneumatically with AN/FO, with the rib holes (holes at the end of each row) containing a 6 foot column of AN/FO and the rest 5 feet. Powder factor was usually 0.9 lbs/cu yd, but could occasionally get as high as 1.2 lbs/cu yd.

I watched and evaluated the drilling, loading and shooting of several rounds. As my observations progressed, several things were noted that had an adverse impact on their blasting results. The first thing I noticed was that, although the mine foreman marked the collar locations accurately, the actual placement and slope angle of the holes varied considerably from driller to driller. (The top row was to be drilled horizontally, while the other two rows inclined upward slightly.) The second thing that became apparent was that the holes were never blown clean between drilling and loading.

The third problem noticed was the condition of the AN/FO that was being loaded with a pressure pot. The blaster had a difficult time loading the holes because of the large amount of fines in the AN/FO. A check of the product showed that there were very few ammonium nitrate prills left intact. (When blowing AN/FO into a horizontal hole, the prills are carried along by a column of air. At the end of the loading hose, the air makes a 180 degree turn and returns via the annular space around the hose. The prills have enough momentum that they can't make the turn and impact into the column that is building. Density of the load is controlled by the velocity of the air in the pipe and, to a lesser extent, the speed at which the blaster withdraws the pipe. If the prills are reduced to fines and powder, they make loading extremely difficult. A lot of the finer material makes the turn and is carried back out of the hole. The fine material that does impact and remain in the hole is usually at a higher density than desired.)

After a round was loaded and connected and the area cleared, it was detonated. The results were definitely not good. There was a considerable amount of AN/FO that did not detonate. There was also a fair amount of blocky ore accompanied by an excessive amount of fines. The explosive and/or method was definitely not doing its job.

In my investigation, I learned that fragmentation had been acceptable up to the time that the mine switched to a new explosive supplier (who happened to be a friend of the new mine superintendent). He convinced the mine that they could save money by switching to 40,000 lb shipments in drop trailers rather than the previous supplier's 15,000 lb deliveries. Under the old scheme, the AN/FO arrived in a bobtail van, was unloaded and then lowered down to the underground magazine. With the new less expensive drop-trailer deliveries, the AN/FO was stored in the trailer on the surface until it was needed.

Some of you may be familiar with the way that elevated temperatures affect prilled ammonium nitrate. For those who aren't, prilled ammonium nitrate undergoes a phase change at a temperature of 90 degrees. At this temperature, ammonium nitrate changes crystalline form, with the higher temperature material having a lower density than its lower temperature counterpart. As the temperature rises above 90 degrees, the AN crystals grow in volume and the prill tends to fall apart. Cycling up and down through 90 degrees accentuates the problem and results in excessive fines. As previously mentioned these fines tend to plug pneumatic loading equipment, are carried back out of the hole more easily during loading and have an impact on the density of the product in the loaded hole. Daytime high temperatures in Southern New Mexico in the summer are often well above 90 degrees and the AN/FO in the drop trailers was cycling and causing problems.

In addition to the problem of loading difficulty was the impact that the density of the loaded product had on its performance. Nearly all explosives have a critical diameter, below which they will not propagate. AN/FO that is properly formulated, is at the correct specific gravity and is properly confined will shoot down to about 1 inch diameter. Increasing the density or changing other parameters can cause the critical diameter to increase. In the case of this potash mine, several things were taking place that affected whether or not the AN/FO would shoot properly. (1) Failure to clean the holes before loading resulted in the occasional spot where the diameter was not a clean 1-5/8". (2) Attempting to load AN/FO that had "cycled" from the elevated surface temperatures not only resulted in a lot of wasted material, but also meant that the AN/FO that did stay loaded in the holes was at a somewhat higher density. (3) This higher density was aggravated slightly by the 4 grain Primaline as it detonated toward the cap in the bottom of the hole. It would blow a small “tunnel” down through the column and the surrounding AN/FO density would be increased further. (4) Another possible contributing factor was the "indirect" priming that was selected when they used the slip-on booster. The initiation was pointed in the wrong direction.

I had some fresh AN/FO delivered (not using any from the surface trailer inventory) and then supervised the loading of a typical round, cleaning out the holes prior to loading, deleting the slip-on boosters and reorienting the cap to point toward the collar. "Spiders" were used to hold the caps centralized in the holes.

The fresh AN/FO loaded quite easily. Although the drilling wasn't perfect, the round shot well and fragmentation was back to being adequate. After two more successful shots I returned to Nevada City to write up my report and make recommendations for future blasting procedures at the mine.

They apparently loaded and shot several more good rounds before management (possibly with encouragement from the powder company) decided to go back to the "less expensive" 40,000 lb drop trailers. Unfortunately, I never learned how their blasting program fared after that, but a few years later the mine was sold and the new owners adopted continuous mechanical miners to harvest the potash rather than conducting any blasting.

Other than the technical issues discussed in this article, there are other lessons to be learned. This was an excellent example of "cheap isn't the least expensive". It also shows how an ill-advised sales attempt on the part of a supplier can actually eliminate a market.

One very eerie experience at this particular mine was caused by the removal of the pillars as they retreated from mined-out areas. As I mentioned, they put in cribbing to temporarily hold the roof while they removed the potash pillars. As they retreated and more pillars were removed, the roof would gradually sag and crush the cribbing at a distance beyond the existing pillars. This creaking and groaning underground was accepted by the old-timers there, but it sure made me feel uncomfortable with 700 feet of mother earth over my head, slowly compressing the timbers.......